BAYOU DORCHEAT TMDL FOR DISSOLVED OXYGEN (SUBSEGMENT 100501)

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FOR DISSOLVED OXYGEN
(SUBSEGMENT 100501)

Prepared for

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EXECUTIVE SUMMARY

Section 303(d) of the Federal Clean Water Act requires states to identify waterbodies that are not meeting water quality standards and to develop total maximum daily loads (TMDLs) for those waterbodies. A TMDL is the amount of pollutant that a waterbody can assimilate without exceeding the established water quality standard for that pollutant. Through a TMDL, pollutant loads can be distributed or allocated to point sources and nonpoint sources discharging to the waterbody. This report presents a TMDL that has been developed for dissolved oxygen (DO) for Bayou Dorcheat (Subsegment 100501) in the Red River basin in north central Louisiana.

Bayou Dorcheat Subsegment 100501 extends approximately 43.5 miles from the Arkansas border south to its confluence with Lake Bistineau, near Minden, Louisiana. Subsegment 100501 covers approximately 940 square miles and is 61% forested.

Subsegment 100501 was included on the final 2004 303(d) list for Louisiana as not fully supporting the designated use of propagation of fish and wildlife and was ranked as priority No. 2 for DO TMDL development. The DO criterion specified in the Louisiana water quality standards for this subsegment is 5 mg/L year-round.

A water quality model (LA-QUAL) was set up to simulate DO, carbonaceous biochemical oxygen demand (CBOD), ammonia nitrogen, and organic nitrogen in Bayou Dorcheat. The model was calibrated to conditions observed during a field survey performed by FTN Associates, Ltd. (FTN) on September 1 - 2, 2005. Depths and widths in the model were based on cross-sections collected during the field survey. Reareation was simulated in the model using the Louisiana Equation. Decay rates for CBOD and ammonia nitrogen were set to averages of values observed during the FTN field survey. Headwater flow rates were based on flows observed during the FTN field survey. Headwater concentrations were based on field data collected by FTN. Model inputs for nonpoint source loads of CBOD and organic nitrogen, benthic loads of ammonia, and sediment oxygen demand were treated as calibration parameters; their values were adjusted until the model output was similar to the calibration target values.

The summer and winter projection simulations were run at critical flows and temperatures to address seasonality as required by the Clean Water Act. Reductions of existing

nonpoint source loads and summer permit limits of one point source were required for the projection simulations to show the DO criterion of 5 mg/L being maintained in the bayou. In general, the modeling in this study was consistent with guidance in the Louisiana TMDL Technical Procedures Manual.

A TMDL for oxygen-demanding substances (CBOD, ammonia nitrogen, organic nitrogen, and sediment oxygen demand) was calculated for summer and winter using the results of the projection simulations. The TMDL calculations included an implicit margin of safety as well as an explicit margin of safety (10% of the TMDL) and an explicit allocation for future growth (also 10% of the TMDL). The wasteload allocation (WLA) for point sources and load allocation (LA) for nonpoint sources was calculated from the loading simulated in the model. Nonpoint source load reductions of 55% in the summer and 34% in the winter were needed for the projection simulations to show the DO criterion of 5.0 mg/L being maintained in the bayou. In addition, permit limits for the Minden Wastewater Treatment Plant (LA0038130) were changed to 5 mg/L for BOD_5 and 1.3 mg/L for ammonia (2 mg/L for ammonia plus organic nitrogen) in the summer projection to achieve the 5 mg/L DO criterion in Bayou Dorcheat. The results of the TMDL calculations for summer and winter are summarized in Tables ES.1 through ES.3.

Table ES.1. Summer DO TMDL for Subsegment 100501 (Bayou Dorcheat).

	Oxygen Demand (kg/day) from:					Oxygen Demand (lbs/day) from:					Percent Reduction Needed
	SOD	CBODu	Organic Nitrogen	Ammonia Nitrogen	Total	SOD	CBODu	Organic Nitrogen	Ammonia Nitrogen	Total	
Point Sources											
WLA	NA	297.71	152.55	132.59	581.86	NA	656.34	336.32	292.31	1282.78	28%
MOS	NA	37.09	19.07	16.57	72.73	NA	81.77	42.04	36.53	160.34	NA
FG	NA	37.09	19.07	16.57	72.73	NA	81.77	42.04	36.53	160.34	NA
Nonpoint Sources											
LA	2213.76	5177.23	413.78	1.24	7806.01	5,137.00	11413.84	912.23	2.73	17209.31	55%
MOS	276.72	647.15	51.72	0.16	975.75	610.06	1426.72	114.02	0.35	2151.16	NA
FG	276.72	647.15	51.72	0.16	975.75	610.06	1426.72	114.02	0.35	2151.16	NA
TMDL	2767.20	6843.42	707.91	167.29	10484.83	6,357.12	15087.16	1560.67	368.8	23115.09	NA

Table ES.2. Winter DO TMDL for Subsegment 100501 (Bayou Dorcheat).

	Oxygen Demand (kg/day) from:					Oxygen Demand (lbs/day) from:					Percent Reduction Needed
	SOD	CBODu	Organic Nitrogen	Ammonia Nitrogen	Total	SOD	CBODu	Organic Nitrogen	Ammonia Nitrogen	Total	
Point Sources											
WLA	NA	468.52	192.66	212.79	873.97	NA	1032.91	424.74	469.12	1926.77	0%
MOS	NA	58.57	24.08	26.60	109.25	NA	129.12	53.09	58.64	240.86	NA
FG	NA	58.57	24.08	26.60	109.25	NA	129.12	53.09	58.64	240.86	NA
Nonpoint Sources											
LA	1360.17	7592.85	726.51	18.68	9698.19	2998.66	16739.37	1601.68	41.18	21380.85	34%
MOS	170.02	949.10	90.81	2.33	1212.27	374.83	2092.41	200.20	5.14	2672.60	NA
FG	170.02	949.10	90.81	2.33	1212.27	374.83	2092.41	200.20	5.14	2672.60	NA
TMDL	1700.21	10076.71	1148.95	289.33	13215.2	3748.32	22215.34	2533	637.86	29134.54	NA

Table ES.3. Flows, concentrations, and loads for point sources included in DO TMDL.

NPDES Number	Name of discharger	Flow rate (gpd)	Concentrations: BOD_5 or $CBOD_5$ (mg/L)	Concentrations: Ammonia Nitrogen (mg/L)	Concentrations: Organic Nitrogen (mg/L)	Loads[B]: BOD_5 or $CBOD_5$ (lbs/day)	Loads[B]: Ammonia Nitrogen (lbs/day)	Loads[B]: Organic Nitrogen (lbs/day)
LA0032301	Cullen WWTP	300,000	10.0	6.08	12.16A	32.39	5.14	2.58
LAG570016	Dixie Inn	4100	10.0	3.33	1.67	8.15	1.18	0.59
LA0038130	Minden WWTP	2440000	10.0	3.33	1.67	133.14	15.40	7.76
LA0005312	Cotton Valley Refinery	392000	15.0	0.0	0.00	63.99	0.00	0.00
LA0020401	Cotton Valley STP	150000	10.0	3.33	1.67	16.32	2.36	4.73
LA0033227	Springhill STP	1500000	5.0/10.0	2.0	4.00[A]	81.61/ 163.23	14.19	28.39
LA0104647	Sarepta STP	150000	10.0	0.0	0.00	16.32	0.00	0.00
LAG541088	Minden Truck Center	7000	30.0	0.0	0.00	2.35	0.00	0.00
LAG540265	Meadowbrook Home	5000	30.0	0.0	0.00	1.57	0.00	0.00
LAG540507	Twin Oaks Subdivision	19000	30.0	0.0	0.00	6.27	0.00	0.00
LAG540538	Oaktree Apartments	11000	30.0	0.0	0.00	3.5	0.00	0.00
LAG540944	Mousers Home Place	16000	30.0	0.0	0.00	5.29	0.00	0.00
100501 Total Loads:						370.9	38.27	44.05

A: Assumed to be two times ammonia nitrogen permit limit.

B: Loads of organic nitrogen and ammonia nitrogen in this table represent loads of nitrogen, not oxygen demand.

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1.0 INTRODUCTION

This report presents a total maximum daily load (TMDL) for dissolved oxygen (DO) for Bayou Dorcheat (Subsegment 100501). This subsegment was cited as being impaired on the final 2004 303(d) list for Louisiana (Louisiana Department of Environmental Quality (LDEQ) 2005). The priority ranking and the suspected sources and suspected causes for impairment from the 303(d) list are presented in Table 1.1. The TMDL in this report was developed in accordance with Section 303(d) of the Federal Clean Water Act and United States Environmental Protection Agency (USEPA) regulations at Title 40 Code of Federal Regulations (CFR) Part 130.7.

The purpose of a TMDL is to determine the pollutant loading that a waterbody can assimilate without exceeding the water quality standard for that pollutant and to establish the load reduction that is necessary to meet the standard in a waterbody. The TMDL is the sum of the wasteload allocation (WLA), the load allocation (LA), future growth (FG), and a margin of safety (MOS). The WLA is the load allocated to point sources of the pollutant of concern. The LA is the load allocated to nonpoint sources, including natural background. The FG is reserved for future increases in loads to the waterbody. The MOS is a percentage of the TMDL that accounts for any lack of knowledge concerning the relationships between pollutant loading and water quality, including uncertainty associated with model assumptions and data inadequacies.

Table 1.1. Summary of 2004 303(d) listing of Subsegment 100501.

Subsegment Number	Waterbody Description	Suspected Sources	Suspected Causes	Priority Ranking (1 = highest)
100501	Bayou Dorcheat	Unknown source	Low DO	2

2.0 STUDY AREA DESCRIPTION

2.1 General Information

Bayou Dorcheat (Subsegment 100501) is located in north central Louisiana in the Red River basin (see Figure A.1 in Appendix A). This subsegment consists of Bayou Dorcheat, from Bayou Dorcheat at the state line to Lake Bistineau, and lies entirely in Webster Parish. The subsegment area is 491.5 square miles. Bayou Dorcheat begins near the Nevada-Columbia county line in Arkansas and travels south for 32 miles to the state line. Bayou Dorcheat then extends approximately 43.5 miles, from the state line south to its confluence with Lake Bistineau near Minden, Louisiana. Bayou Dorcheat drains a total of 1443 square miles, of which 502 square miles are in Arkansas. As shown in Figure A.1, the subsegment does not include Caney Creek (a tributary of Bayou Dorcheat) or Caney Lake (they are in a separate subsegment since they have a different designated uses than Bayou Dorcheat; see Section 2.3).

2.2 Land Use

Land use characteristics for the Bayou Dorcheat drainage area were compiled from the United States Geological Survey (USGS) 2001 National Land Cover Database (USGS 2006). These data are the most recent land use data that are currently available for this area. The spatial distribution of these land uses is shown on Figure A.2 (located in Appendix A) and land use percentages are shown in Table 2.1. These data indicate that the primary land use in this subsegment is forest. It should be noted that a portion of the watershed has been incorrectly identified as wetlands and should be classified as water, but in many areas, Bayou Dorcheat bifurcates and enters swamps.

Table 2.1. Land uses in Subsegment 100501.

Land Use Type	% of Total Area
Water	1.0%
Urban/Transportation	9.2%
Barren	0.1%
Forest	61.2%
Shrubland/grassland	13.2%
Pasture/hay	4.5%
Cultivated crops	0.2%
Wetlands	10.6%
TOTAL	100.0%

2.3 Water Quality Standards

Water quality standards for Louisiana are included in the Title 33 Environmental Regulatory Code (LDEQ 2006a). The designated uses for Bayou Dorcheat are primary contact recreation, secondary contact recreation, propagation of fish and wildlife, agricultural water supply, and outstanding natural resource water. The primary numeric criteria for the TMDL presented in this report are the DO criterion of 5 mg/L (year-round) and the temperature criterion of 32°C.

The Louisiana water quality standards also include an anti-degradation policy (LAC 33:IX.1109.A). This policy states that waters exhibiting high water quality should be maintained at that high level of water quality. If this is not possible, water quality of a level that supports designated uses of the waterbody should be maintained. Changing the designated uses of a waterbody to allow a lower level of water quality can only be achieved through a use attainability study.

2.4 Identification of Sources

2.4.1 Point Sources

A list of point sources in selected portions of the Red River basin was developed using data from LDEQ's internal point source databases with additional information obtained from LDEQ’s Electronic Document Management System. Using this information, 21 National Pollutant Discharge Elimination System (NPDES) permits were identified within

Subsegment 100501 and were discharging directly or indirectly to Bayou Dorcheat. The point sources are listed in Table B.1 in Appendix B. Of the 21 point sources, three had large enough oxygen-demand loads and were close enough to Bayou Dorcheat that it was assumed they would impact Dorcheat (i.e., their loads would not be assimilated by the time their effluent reached Bayou Dorcheat) and thus were included in the model. Ten additional point sources were included in the TMDL calculations for this subsegment. The remaining point sources were not considered to be significant sources of oxygen demand and thus were neither modeled nor included in the TMDL. A map showing the location of all 21 discharges is shown in Appendix A in Figure A.3.

2.4.2 Nonpoint Sources

The nonpoint source in the Bayou Dorcheat subsegment (100501) cited as the suspected source of impairment in the 303(d) list (Table 1.1) was unknown.

2.5 Historical Data Summary

There are two LDEQ stations in this subsegment: Station 0061 (Bayou Dorcheat west of Minden, Louisiana) and Station 0274 (Bayou Dorcheat west of Sibley, Louisiana). They are both long-term stations, with a data record for Station 0061 from June 1958 to December 2002, and for Station 0274 from February 1990 to April 1998. However, since only data collected between January 1, 1997, and December 31, 2002, were compiled by LDEQ to assess Bayou Dorcheat for the 2004 303(d) listing, not all the available data collected at Stations 0061 and 0274 were used for the state assessment. It should be noted that no data were collected at Station 0061 between 1990 and 2001. The data for the period of record are summarized in Table 2.2 below, including the number and percentage of DO criterion violations. The station locations are shown in Figure A.1 in Appendix A and a complete tabular listing of all the data for both stations is shown in Tables C.1 and C.2 in Appendix C.

Table 2.2. Water quality data collected by LDEQ.

Station No.	Station Description	Period of Record	Count	Min.	Median	Average	Max.	Number Below Standard	% Below Standard
0061	Bayou Dorcheat west of Minden, Louisiana	June 1, 1958 – Jan. 29, 2007	381	1.90	6.80	7.13	20.10	44	11.5%
0274	Bayou Dorcheat west of Sibley, Louisiana	Feb. 12, 1990 – Apr. 13, 1998	50	3.06	7.35	6.94	10.68	10	20.0%

In addition to the LDEQ data, the Arkansas Department of Environmental Quality (ADEQ) has collected water quality data on three sites in the Arkansas portion of Bayou Dorcheat. These data were compared to the LDEQ water quality standard (the Arkansas standard is different). As shown below in Table 2.3, the water quality is similar on both sides of the state line. It also should be noted that the Arkansas portion of Bayou Dorcheat is not listed for DO. The raw data from these stations are shown in Tables C.3 through C.5 in Appendix C. The most upstream of the three stations (UWBDT01) is 32.5 miles upstream from the state line (on the Columbia - Nevada County border).

Table 2.3. Water quality data collected from Bayou Dorcheat by ADEQ.

Station No.	Station Description	Period of Record	Count	Min.	Median	Average	Max.	Number Below Standard	% Below Standard
RED0015A	Dorcheat Bayou east of Taylor, Arkansas	Oct. 16,1990 – May 15,2007	167	2	6.74	6.90	17.38	27	16.2%
UWBDT01	Bayou Dorcheat at Hwy 355	June 20,1994 – Oct. 8,1996	9	2.3	5.00	5.38	10.7	4	44.4%
UWBDT02	Bayou Dorcheat at Hwy 82, near Waldo	June 20,1994 – Sep. 18,2000	20	1.5	4.60	5.27	11.3	11	55.0%

2.6 Previous Studies

Several reports were obtained from LDEQ that were quite useful and had data used for this TMDL. Listed below are the previous studies in the Bayou Dorcheat subsegment that were used by FTN.

1. "A Waste Load Allocation for the Minden Municipal Wastewater Treatment Facilities" Prepared by Limnotech for the Louisiana Department of Natural Resources dated December of 1984. This report used a calibrated and verified QUAL-II model to simulate the two facilities used by the city of Minden to treat their wastewater and to determine the wasteload allocation for these facilities. Two surveys were completed to gather data for the model, one on June 7 through 8, 1983 and the other on August 16 through 17, 1984. The surveys collected both in situ and grab samples at a total of 18 stations in Cooley Branch, Ten Mile Creek, and Bayou Dorcheat. Both surveys showed Ten Mile Creek below the discharge and Bayou Dorcheat had DO violations, whereas Cooley branch had fewer violations, and both Cooley Branch and Ten Mile Creak had no DO violations above the STP. The model recommended the most stringent possible limits (5 mg/L BOD_5, 5 mg/L TSS, 2 mg/L ammonia, and 5 mg/L effluent DO) to minimize water quality degradation since even with those limits a 5 mg/L DO could not be maintained in Minden or Cooley Branch. However these impacts will not extend into Bayou Dorcheat.
2. "Springhill Little Crooked Creek Wasteload Allocation" prepared by Center For Louisiana Inland Water Studies Civil Engineering Department University of Southern Louisiana for Engineering Section Water Pollution Control Division Office of Water Resources Louisiana Department of Environmental Quality dated December of 1990. LIMNOSS was used to determine a waste load allocation for the Springhill Wastewater Treatment plant. Data from two surveys (one in 1988 and one in 1990) were used to calibrate the model. The 1988 survey consisted of in situ, flow, and grab samples taken at eight stations on Crooked Creek, Little Crooked Creek and Taylor Branch. The surveys revealed poor water quality and were taken under drought (i.e. critical) conditions. The model developed two sets of limits, one for summer (April through October) and one for winter (November through March). The summer limits were 5 mg/l $CBOD_5$, 2 mg/L ammonia, and an effluent DO of 5 mg/L while the winter limits were 10 mg/L $CBOD_5$, 2 mg/L ammonia and an effluent DO of 5 mg/L. Even with these limits the minimum DO for summer was predicted to be 2.27 mg/L and the winter minimum DO was predicted to be 3.03 mg/L. However in both cases the stream had recovered before it reached Bayou Dorcheat.
3. "A Wasteload Allocation for the Cotton Valley Municipal Wastewater Treatment Facility" prepared for Louisiana Department of Natural Resources by Limnotech dated October 1983. A Streeter-Phelps model developed by Limnotech was used

to calculate a wasteload allocation for the Cotton Valley STP and the Cotton Valley Refinery. An intensive survey was conducted on May 4 through 5, 1982 to assess the stream water quality and provide information for the stream model. Water quality samples were taken at six stations on French Creek (both upstream and downstream of the Cotton Valley STP), and samples were also taken of the effluent from the two plants. Several DO violations were observed during the survey. With the highest level of treatment (5 mg/L BOD_5, 5 mg/L TSS, and 2 mg/L ammonia) the DO standard of 2 mg/L could not be achieved and anoxic conditions would still exist.

3.0 FTN INTENSIVE SURVEY

FTN conducted a field survey for 14 subsegments in the Red River and Sabine River basins during August 31 through September 9, 2005. Low flow conditions existed throughout the survey area during this time. The survey was conducted after Hurricane Katrina and before Hurricane Rita. Hurricane Katrina did not cause any noticeable impacts on water quality in the survey area. Field data were collected in the Flat River subsegment on August 31 through September 2, 2005.

The field survey included water quality sampling and corresponding in situ measurements at various locations; measurements of flow, depth, and width at several locations; and continuous in situ monitoring at several locations. The water quality samples were analyzed for 20-day CBOD time series, total Kjeldahl nitrogen (TKN), ammonia nitrogen (NH_3-N), nitrate+nitrite nitrogen, total phosphorus, chlorophyll *a*, total organic carbon (TOC), and total suspended solids (TSS). A list of the survey sites and the type of data collected at each site is presented in Table D.1 (Appendix D). The in situ measurements and water quality sampling results are summarized in Tables D.2 and D.3, respectively. The calculations of CBOD decay rates and ultimate CBOD (CBODu) concentrations from the time series data are shown in Table D.4.

FTN collected data at a total of four sites in the subsegment. In situ and lab data were gathered at Station 100501-A (Bayou Dorcheat near the Arkansas state line) and Station 100501-B (Bayou Dorcheat northeast of Cotton Valley), while only in situ data were taken at Station 0061 (Bayou Dorcheat at Highway 80) and Station 0274 (Bayou Dorcheat at Highway 164). The data for these stations are summarized in Table 3.1. It should be noted that three of the four DO values are greater than 5 mg/L. The one DO value that is less than 5 mg/L (3.2 mg/L) was taken at 2:35 pm, when DO concentrations tend to be highest (DO concentrations usually peak in the late afternoon).

Table 3.1. FTN field data collected for Subsegment 100501.

	Station 100501-A	Station 100501-B	Station 0061	Station 0274
Date and time of sample / measurements	9/1/05 2:35 pm	9/1/05 3:55 pm	9/1/05 6:45 pm	9/2/05 9:40 am
Depth (m) of sample / measurements	0.4572/0.152[A]	0.305[B]	0.61	1.0
Water temperature (°C)	27.1	31.8	23.6	29.1
DO (mg/L)	3.2	5.9	7.1	6.2
Conductivity (µmhos/cm)	418	76	127	193
pH (su)	7.1	7.2	6.7	7.6
TSS (mg/L)	11	4.4	--	--
TKN (mg/L)	1.6	1.7	--	--
Total phosphorus (mg/L)	0.15	0.048	--	--
TOC (mg/L)	5.7	8.3	--	--
Chlorophyll *a* (µg/L)	< 0.02	0.021	--	--
NH_3-N (mg/L)	0.2	0.18	--	--
Nitrate+nitrite nitrogen (mg/L)	0.26	< 0.05	--	--
CBOD on day 2 of analysis (mg/L)	2.4	5.2	--	--
CBOD on day 5 of analysis (mg/L)	3.2	6.5	--	--
CBOD on day 9 of analysis (mg/L)	3.9	7.6	--	--
CBOD on day 14 of analysis (mg/L)	4.2	7.9	--	--
CBOD on day 20 of analysis (mg/L)	4.8	12	--	--
CBODu (mg/L; calculated)	4.43	10.13	--	--
CBOD decay rate (1/day; calculated)	0.3	0.21	--	--
Flow	low[c]	low	0.04 fps	low

A. The in situ data were taken at 1.5 ft (0.4572 m) while the sampling data were taken at 0.5 ft (0.152 m).
B. This is the depth of just the in situ measurements.
C. Although flow was observed, the flow was too small to measure with the drogue the survey crew used.

4.0 CALIBRATION OF WATER QUALITY MODEL

4.1 Model Setup

In order to evaluate the linkage between pollutant sources and water quality, a computer simulation model was used. The model used for this TMDL was LA-QUAL (Version 8.11), which was selected because it includes the relevant physical, chemical, and biological processes and has been used successfully in the past for other TMDLs in Louisiana. The LA-QUAL model was set up to simulate organic nitrogen, ammonia nitrogen, CBODu, and DO.

Figure E.1 in Appendix E shows the model reach design and the location of the modeled inflows. Bayou Dorcheat was divided into eight reaches to represent varying depths and widths along the stream. Braley and Ten Mile Creeks were modeled as branches to the system since each had an oxygen-demanding point source that would potentially affect Bayou Dorcheat. Braley Creek was modeled as one reach, while Ten Mile Creek consisted of four reaches. All reaches were divided into smaller elements to take into account variations in water quality along their length.

4.2 Calibration Period and Calibration Targets

Routine water quality monitoring has been conducted at two long-term LDEQ sampling stations: Station 0061, Bayou Dorcheat near Minden (from 1958 to 2002), and Station 0274, Bayou Dorcheat west of Sibley (from 1990 to 1998). An intensive survey of this subsegment was performed by FTN on September 1 – 2, 2005, and water quality data were collected at two sites (Stations 100501-A and 100501-B) in addition to LDEQ Stations 0061 and 0274. The water quality data collected by both LDEQ and the FTN intensive survey are discussed in Section 2.5 and compiled in Appendices C and D.

The two conditions that usually characterize critical periods for DO are high temperatures and low flows. High temperatures decrease DO saturation values and increase rates for oxygen-demanding processes (biochemical oxygen demand (BOD) decay, nitrification, and sediment oxygen demand (SOD)). In most systems, low flows cause reaeration rates to be lower.

The purpose of selecting a critical period for calibration is so that the model will be calibrated as accurately as possible for making projection simulations for critical conditions.

The model was calibrated to the FTN intensive survey. This period represented the critical period for DO. The calibration target (i.e., the concentration to which the model was calibrated) for each parameter was set equal to the concentrations measured during the survey, with the exception of DO, which was set equal to estimated daily minimum DO plus 1 mg/L (as opposed to the in situ measured DO). For stations without continuous data, a minimum daily DO was estimated. This was done by calculating the ratio of the minimum DO to the instantaneous DO at a continuous monitoring station and then dividing the instantaneous DO measured at another in situ station by this ratio. These calculations are shown in Tables D.5 through D.7 in Appendix D. Organic nitrogen was estimated as TKN minus the ammonia nitrogen value.

4.3 Temperature Correction of Kinetics (Data Type 4)

The temperature correction factors used in the model were consistent with the Louisiana Technical Procedures Manual (LTP; Aguillard and Duerr 2006). These correction factors were:

1. Correction for BOD decay: 1.047 (value in LTP is same as model default)
2. Correction for SOD: 1.065 (value in LTP is same as model default)
3. Correction for ammonia N decay: 1.070 (specified in Data Group 4)
4. Correction for organic N decay: 1.020 (not specified in LTP; model default used)
5. Correction for reaeration: automatically calculated by the model

4.4 Hydraulics (Data Type 9)

The hydraulics were specified in the input for the LA-QUAL model using the power functions (width = $a * Q^b + c$ and depth = $d * Q^e + f$). The typical width and depth of the reaches of the Bayou Dorcheat branch were based on cross-section data collected by FTN during the intensive survey. Additional stream widths were measured from Digital Ortho Quarter Quads. Depth and width data for Braley and Ten Mile Creeks were taken from LIMNOSS models made for LDEQ by Tetra Tech (discussed in Section 2.6). Plots of the typical width and depth for each reach along with the measured data are included in Table F.1 in Appendix F.

4.5 Initial Conditions (Data Type 11)

Because temperature is not being simulated in the model, the temperature for the reaches was specified in the initial conditions for LA-QUAL. The temperature for all of the reaches was set to the temperature measured in that reach during the intensive survey. For reaches with no temperature measured, one was estimated. The same method was used to determine the initial DO concentrations, except that instead of using measured DO values, the calibration targets (min DO + 1 mg/L) were entered. Since there were only two measured values of ammonia from the FTN survey, the two values were averaged and then used for all 13 reaches. Chlorophyll concentrations were also included in the initial conditions. The averaged of the two measured values was used for all of the reaches. The input data and sources are shown in Table F.2 in Appendix F.

For all other constituents not being simulated, the initial concentrations were set to zero. Otherwise the model would have assumed a fixed concentration of those constituents and the model would have included effects of the unmodeled constituents on the modeled constituents.

4.6 Water Quality Kinetics (Data Types 12 and 13)

Kinetic rates used in LA-QUAL include reaeration rates, CBOD decay rates, nitrification rates, and mineralization rates (organic nitrogen decay). The values used in the model input are shown in Table F.3 in Appendix F.

For reaeration, the Louisiana Equation (option 15) was specified in the model for Braley and Ten Mile Creeks because it was developed specifically for streams in Louisiana, it has been used successfully in the past for other TMDLs in Louisiana, and Braley and Ten Mile Creeks are narrow streams. However, wind-aided reaeration was used for Bayou Dorcheat, because it has a large width and in some places behaves more like a lake than a stream. A wind-aided reaeration rate was calculated based on the mean daily windspeed for Shreveport Regional Airport on September 1, 2005, and yielded a rate of 0.97 m/day. This calculation is shown in Appendix G.

This rate was applied to reaches 4 and 13 (the two widest reaches, where it was assumed that wind-aided reaeration would take place to its fullest effect). For all the other main stream reaches, a value was interpolated between the calculated value (0.97 m/day) and a minimum value (0.70 m/day) based on the width of the reach (the wider the stream, the more wind-aided reaeration would occur).

The CBOD decay rate was set equal to 0.15/day. This was based on a summary of the calculated laboratory BOD decay rates for 140 LDEQ survey stations in the Ouachita and Calcasieu river basins, and the calculated laboratory decay rates from the FTN intensive survey. The maximum decay rate for stations in subsegments with at least 70% forest (Subsegment 100501 was over 60% forested) was 0.07/day; the average and median rates were both 0.04/day (the data are shown in Appendix H). The CBOD decay from the FTN survey varied between 0.30/day (100501-A) and 0.21/day (100501-B). Thus, a decay rate of 0.15/day was higher than the values from the LDEQ survey but lower than the values from the FTN survey.

The nitrification rate was based on analyzing NBOD decay rates measured in the LDEQ survey of Ouachita and Calcasieu river basins. Only NBOD decay rates from subsegments with more than 70% forest land cover were used. These measured rates were averaged and this computation is shown in Appendix H.

The mineralization rates (organic nitrogen decay) in the model were set to 0.02/day for all reaches. This value was similar to the values shown in Table 5.3 of the “Rates, Constants, and Kinetics” publication (USEPA 1985) for dissolved organic nitrogen being transformed to ammonia nitrogen.

4.7 Nonpoint Source Loads (Data Type 19)

The nonpoint source loads that are specified in the model can be most easily understood as resuspended load from the bottom sediments and are modeled as SOD, benthic ammonia source rates, CBOD loads, and organic nitrogen loads. The SOD (specified in Data Type 12), the benthic ammonia source rates (specified in Data Type 13), and the mass loads of organic nitrogen and CBODu (specified in Data Type 19) were all treated as calibration parameters; their values were adjusted until the model output was similar to the calibration target values. The values used as model input are shown in Table F.4 in Appendix F.

Typically, these four calibration parameters were adjusted in a specific order based on the interactions between state variables in the model. First, the organic nitrogen loads were adjusted until the predicted organic nitrogen concentrations were similar to the observed concentrations. Organic nitrogen was calibrated first because none of the other state variables will affect the organic nitrogen concentrations. Next, the benthic ammonia source rates were adjusted until the predicted ammonia nitrogen concentrations were similar to the observed concentrations. Then the CBODu loads were adjusted until the predicted CBODu concentrations were similar to the observed concentrations. Finally, the SOD rates were adjusted until the predicted DO concentrations were similar to the observed concentrations. The SOD rate was not adjusted below 0.5 g/m^2/day. The DO was calibrated last because all of the other state variables affect DO.

4.8 Headwater Flow and Tributary Rates (Data Types 20 and 24)

Headwater inflow rates were specified for the three branches of the model. The inflow rates for Bayou Dorcheat, Ten Mile Creek, and Braley Creek were estimated by multiplying the estimated headwater drainage area (501 mi^2, 39.24 mi^2, and 0.55 mi^2, respectively) by the average flow per unit area for the basin measured at the USGS flow gage at Bayou Dorcheat near Springhill, Louisiana (USGS Gage No. 07348700) during the FTN survey. These calculations are included in Tables F.5 and F.6. in Appendix F.

4.9 Headwater and Tributary Water Quality (Data Types 21, and 25)

Concentrations of DO, CBODu, organic nitrogen, and ammonia nitrogen were specified in the model for the three headwater flows. Water quality for the Bayou Dorcheat headwater was set to the concentrations measured at 100501-A, with the exception of DO. Instead of the measured value, the DO calibration target (Section 4.2) was used. Water quality had to be estimated for headwaters of Ten Mile Creek, and Braley Creek, and for four tributaries: a tributary of Braley Creek, Indian Creek, Black Bayou, and Flat Lick Bayou.

Of these, Ten Mile Creek, Braley Creek, and Braley Creek Tributary drain a small heavily forested area, so the same water quality was used for all these inflows. Measured water quality data from the intensive survey was analyzed to determine representative water quality for small heavily forested watersheds with no point sources on them. Five stations were found to fit this description: Station 570 (Beaver Creek west of Faircloth, Louisiana; Subsegment 101302), Station 110401-A (Toro Creek southeast of Florien, Louisiana; Subsegment 110401), Station 100602-A (Boggy Bayou southeast of Hicks Crossing, Louisiana; Subsegment 100602), Station 1207 (Boggy Bayou southwest of Shreveport, Louisiana; Subsegment 100602), and Station 100405-A (Black Bayou near Benton, Louisiana; Subsegment 100405). CBODu was calculated for all of these stations with the exception of Station 570, where the BOD was below the detection limit (2 mg/L) for all five measured values so no rate could be calculated. For all the other parameters, when a value was not detected, it was set equal to its detection limit.

The process above was repeated to get estimated water quality for large forested watersheds with very few point sources to use for Indian Creek, Black Bayou, and Flat Lick Bayou. Estimated water quality was based on data from Station 100702-B (Leatherman Creek west of Mt. Lebanon, Louisiana; Subsegment 100702), Station 282 (Black Lake Bayou west of Castor, Louisiana; Subsegment 100702), Station 1187 (Black Lake Bayou at Highway 155, east of Martin, Louisiana; Subsegment 100702), Station 100703-A (Black Lake northeast of Campti, Louisiana; Subsegment 100703), Station 101302-A (Iatt Creek near upstream end of Iatt Lake; Subsegment 101302), and Station 1160 (Bayou Toro northeast of Toro, Louisiana; Subsegment 110401). The measured ammonia nitrogen, TKN, CBODu, and DO calibration targets (Section 4.2) were averaged for the inputs. The values used as model input are shown in Table F.7 in Appendix F and the averaging of the values for the tributaries are shown in Tables I.1 and I.2 in Appendix I.

4.10 Point Source Inputs (Data Types 24 and 25)

Three NPDES-permitted dischargers in the Bayou Dorcheat subsegment were included in the model. The point source flows and water quality concentrations were set to average effluent concentrations reported on their discharge monitoring reports (DMRs) for September 2005. The reported $CBOD_5$ or BOD_5 was multiplied by 2.3 to get CBODu. When available, monthly average values were used. In the case of the City of Minden and the City of Dixie Inn Village, there were no ammonia values reported on the discharge monitoring reports. Advanced treatment permit limits were assumed for these two point sources: 10 mg/L $CBOD_5$ and 5 mg/L of nitrogen (ammonia nitrogen plus organic nitrogen). Two-thirds of the nitrogen was assumed to be ammonia, and one-third was assumed to be organic nitrogen based on the LTP and assuming mechanical treatment plants. The values used as model inputs are shown in Table F.8 in Appendix F.

4.11 Model Results for Calibration

Plots of predicted and observed water quality for the calibration and a printout of the LA-QUAL output file are presented in Appendix J. The calibration was considered to be acceptable based on the amount of data that were available.

5.0 WATER QUALITY MODEL PROJECTION

USEPA's regulations at 40 CFR 130.7 require the determination of TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. Therefore, the calibrated model was used to project water quality for critical conditions. The identification of critical conditions and the model input data used for critical conditions are discussed below.

5.1 Identification of Critical Conditions

Section 303(d) of the Federal Clean Water Act and USEPA's regulations at 40 CFR 130.7 both require the consideration of seasonal variation of conditions affecting the constituent of concern and the inclusion of an MOS in the development of a TMDL. For the TMDL in this report, analyses of LDEQ long-term ambient data were used to determine critical seasonal conditions. Both an implicit MOS and an explicit MOS were used in developing the projection model.

Critical conditions for DO have been determined for Louisiana waterbodies in previous TMDL studies. These analyses concluded that critical conditions for stream DO concentrations occur during periods with negligible nonpoint runoff, low stream flow, and high stream temperature.

When the rainfall runoff (and nonpoint loading) and stream flow are high, turbulence is higher due to the higher flow and the stream temperature is lowered by the cooler precipitation and runoff. In addition, runoff coefficients are higher in cooler weather due to reduced evaporation and evapotranspiration, so that the high flow periods of the year tend to be the cooler periods. DO saturation values are much higher when water temperatures are cooler, but BOD decay rates are much lower. For these reasons, periods of high loading are periods of higher reaeration and higher DO concentrations, but not necessarily periods of high BOD decay.

LDEQ interprets this phenomenon in its TMDL modeling by assuming that the annual nonpoint loading, rather than loading for any particular day, is responsible for the accumulated benthic blanket of the stream, which is, in turn, expressed as SOD and/or resuspended BOD in the model. This accumulated loading has its greatest impact on the stream during periods of higher temperature and lower flow.

According to the LTP, critical conditions in DO TMDL projection modeling for summer and winter are simulated by using the seasonal 7Q10 flow or 0.1 cubic feet per second (cfs) for summer or 1.0 cfs for winter (whichever is higher) for all headwaters, and 90th percentile temperatures for the season. Model loading is from perennial tributaries, point sources, SOD, and resuspension of sediments.

In reality, the highest temperatures occur in July and August and the lowest stream flows occur in October and November. The combination of these conditions plus the impact of other conservative assumptions regarding rates and loadings yields an implicit MOS that is not quantified. Over and above this implicit MOS, an explicit MOS of 10% for nonpoint sources and an explicit MOS of 20% for point sources were incorporated into the TMDLs in this report to account for model uncertainty.

5.2 Temperature Inputs

The LTP (Aguillard and Duerr 2006) specified that the critical temperature should be determined by calculating the 90th percentile seasonal temperature for the waterbody being modeled. There are two LDEQ stations on Bayou Dorcheat with long-term temperature records (Stations 0071 and 0124). 90th percentile temperatures were determined for both stations. The summer and winter temperatures for the projection models were set to the average of these 90th percentile temperatures (30.8ºC for summer, and 19.6ºC for winter). These values were specified in Data Type 11 in the model and are shown in Appendix K, along with the values used to calculate the 90th percentile temperatures.

5.3 Headwater and Tributary Inputs

The inputs for the headwaters and tributaries for the projection simulations were based on guidance in the LTP. As specified in the LTP, the DO concentrations for the headwater and tributary inflows were set to 90% saturation at the critical temperatures (Section 5.2). Concentrations for other parameters were set to calibration values. The calculations for the DO values used for the headwaters and tributaries in the projection simulations are shown in Appendix K.

Headwater flows were set to either the 7Q10 flow or 0.1 cfs (1.0 cfs for winter), whichever was greater. 7Q10 flows were obtained for Bayou Dorcheat from the USGS technical report, Low-Flow Characteristics of Louisiana Streams (2003). The published 7Q10 flow for summer is 0.60 cfs, and the published flow for winter is 14 cfs. For the tributaries, flows were either published or assumed to be zero, so 0.1 cfs was used for summer, and 1.0 cfs was used for winter flow conditions for tributaries in the projection modeling. The model input files used in the projection simulations are shown in Appendix L.

It was assumed that headwater and tributary water quality would improve with reductions of nonpoint source loads in the watershed. For the projection simulations, the headwater and tributary concentrations of CBODu, organic nitrogen, and ammonia nitrogen were reduced from the calibration simulation values by the same percentages as the reduction of nonpoint source loads (see Section 5.5 for reductions applied to nonpoint source loads). The values used as model inputs for headwater and tributary concentrations are summarized in Table 5.1.

Table 5.1. Headwater concentrations used in each simulation.

		CBODu (mg/L)	**Organic Nitrogen (mg/L)**	**Ammonia Nitrogen (mg/L)**	**DO (mg/L)**
Calibration	Dorcheat Tributaries	4.43 12.5	1.40 1.42	0.20 0.20	2.10 3.78
Summer projection (55% reduction)	Dorcheat Tributaries	1.99 5.63	0.63 0.64	0.09 0.09	6.71 6.71
Winter projection (34% reduction)	Dorcheat Tributaries	2.92 8.25	0.92 0.94	0.13 0.13	8.25 8.25

5.4 Point Source Inputs

Flows for the NPDES-permitted point sources included in the projection simulations were set to 1.25 times the design flows to allow for an MOS. For the Cullen STP, 0.011 m^3/s was used; for the Minden STP, 0.134 m^3/s; and for Dixie Inn STP, 0.0041 m^3/s was used. Point source CBODu was set to 2.3 times the BOD_5 permit limits. The ammonia concentration for the

Cullen STP was set to the permit limit and organic nitrogen was set to 2 times the ammonia limit. The remainder of the point source water quality inputs were the same as in the calibration model.

5.5 Point Source Loads

With no reductions in point source permitted loads, the summer projection simulation indicated nonpoint sources would need to be reduced 70% to meet the DO criterion. The wasteload allocation study for the Minden municipal wastewater treatment facilities discharging to Cooley Branch and Mile Creek concluded that this system would not likely be able to assimilate more than discharges of 5 mg/L BOD_5, 2 mg/L ammonia, and 5 mg/L DO (Limno-Tech 1984). Therefore, the summer projection simulation was run with Minden wastewater treatment plant (WWTP) effluent concentrations set to the recommended limits from the allocation study (5 mg/L BOD_5, 1.3 mg/L ammonia, 0.7 mg/L organic nitrogen, and 5 mg/L DO). Changing the Minden WWTP inputs did not change the results of the winter projection simulation. Therefore, the winter projection was run with the existing Minden WWTP permit limit (10 mg/L BOD5), and nitrogen concentrations from the calibration (3.3 mg/L ammonia, and 1.7 mg/L organic nitrogen). Wasteload allocation studies were not available for the other point sources included in the model, so there was little justification for lowering their permit limits.

5.6 Nonpoint Source Loads

Because the initial projection simulations were showing low DO values, the nonpoint source loadings were reduced until all of the predicted DO values were equal to or greater than the water quality criterion of 5.0 mg/L. The same percent reduction was applied to the SOD and nonpoint source mass loads of CBODu and organic nitrogen. SOD was not reduced below 0.4 g/m^2/day. The model input files used in the projection simulations are shown in Appendix L.

5.7 Other Inputs

The only model inputs that were changed from the calibration to the projection simulations were the inputs discussed above in Sections 5.2 through 5.5. Other model inputs (e.g., hydraulic coefficients, decay rates, reaeration equations, etc.) were unchanged from the calibration simulation.

5.8 Model Results for Projection

Plots of predicted water quality for the projections are presented in Appendix L, along with printouts of the LA-QUAL output files.

Oxygen-demanding load reductions were required to meet the DO standard. Nonpoint source load reductions of approximately 55% for summer and 34% for winter were required to bring the predicted DO values to at least 5.0 mg/L. These percent reductions for nonpoint source loads represent percentages of the entire nonpoint source loading, not percentages of the manmade nonpoint sources. The nonpoint source loads in this model were not separated into natural and manmade nonpoint sources, because it would be difficult to accurately estimate natural nonpoint source loads for the study area.

6.0 TMDL CALCULATIONS

6.1 DO TMDL

A TMDL for DO has been calculated for the Bayou Dorcheat subsegment based on the results of the projection simulation. The DO TMDL is presented as oxygen demand from CBODu, organic nitrogen, ammonia nitrogen, and SOD. Summaries of the loads for Bayou Dorcheat are presented in Tables 6.1 through 6.3 (located at the end of this section).

The TMDL calculations were performed using a FORTRAN program that was written by FTN personnel. This program reads two files; one is the LA-QUAL output file from the projection simulation, and the other is a small file with miscellaneous information needed for the TMDL calculations (shown in Appendix M). The output from the program is also shown in Appendix M. The source code for the program is shown in Appendix N.

The oxygen demand from organic nitrogen and ammonia nitrogen was calculated as 4.33 times the nitrogen loads (assuming that all organic nitrogen is eventually converted to ammonia). The value of 4.33 is the same ratio of oxygen demand to nitrogen that is used by the LA-QUAL model. For the SOD loads, a temperature correction factor was included in the calculations (in order to be consistent with LDEQ procedures).

6.2 Ammonia Toxicity Calculations

Although Subsegment 100501 is not on the Louisiana 303(d) list for ammonia, the ammonia concentrations predicted by the projection models were checked to make sure that they did not exceed USEPA criteria for ammonia toxicity (USEPA 1999). The USEPA criteria are dependent on temperature and pH. The critical temperatures used in the projection simulations were used to calculate the seasonal ammonia toxicity criteria for Bayou Dorcheat. For pH, seasonal averages of the values measured at LDEQ Stations 0061 and 0124 were used. The resulting criteria were 2.2 mg/L of ammonia nitrogen for summer, and 4.67 mg/L of ammonia nitrogen for winter. Some of the summer instream ammonia nitrogen concentrations predicted by the LA-QUAL model for Braley Creek were above the ammonia toxicity criterion (Appendix O). This indicates that ammonia nitrogen loadings that will maintain the DO standard in Bayou

Dorcheat may exceed the USEPA ammonia toxicity criteria in Braley Creek during the summer. The summer instream ammonia nitrogen concentrations predicted by the LA-QUAL model for Bayou Dorcheat were well below the criterion, as were all of the predicted winter instream ammonia nitrogen concentrations. This indicates that the ammonia nitrogen loadings that will maintain the DO standard are low enough that the USEPA ammonia toxicity criteria will not be exceeded under critical conditions in Bayou Dorcheat. The ammonia toxicity calculations are shown in Appendix O.

6.3 Summary of Point Source Reductions

In summary, the projection modeling used to develop the TMDLs indicated that point source loads needed to be reduced to maintain the DO criterion during summer critical conditions. Concentrations of BODu, ammonia, and organic nitrogen were reduced in Minden WWTP effluent. This resulted in a 28% reduction in point source loads.

6.4 Summary of NPS Reductions

In summary, the projection modeling used to develop the TMDLs above showed that nonpoint source loads needed to be reduced by 55% in the summer and 34% in the winter to maintain the DO criterion in lower Bayou Dorcheat (Subsegment 100501).

6.5 Seasonal Variation

As discussed in Section 4.1, critical conditions for DO in Louisiana waterbodies have been determined to be when there is negligible nonpoint runoff and low stream flow combined with high water temperatures. In addition, the model accounts for loadings that occur at higher flows by modeling SOD. Oxygen-demanding pollutants that enter the waterbodies during higher flows settle to the bottom and then exert the greatest oxygen demand during the high temperature seasons.

6.6 Margin of Safety

The MOS accounts for any lack of knowledge or uncertainty concerning the relationship between load allocations and water quality. As discussed in Section 4.1, the highest temperatures occur in July and August, the lowest stream flows occur in October and November. The combination of these conditions, in addition to other conservative assumptions regarding rates and loadings, yields an implicit MOS, which is not quantified. In addition to the implicit MOS, the TMDL in this report includes an explicit MOS of 10% for nonpoint source loads and an explicit MOS of 20% for point source loads.

Table 6.1. Summer DO TMDL for Subsegment 100501 (Bayou Dorcheat).

	Oxygen Demand (kg/day) from:					Oxygen Demand (lbs/day) from:					Percent Reduction Needed
	SOD	CBODu	Organic Nitrogen	Ammonia Nitrogen	Total	SOD	CBODu	Organic Nitrogen	Ammonia Nitrogen	Total	
Point Sources											
WLA	NA	297.71	152.55	132.59	581.86	NA	656.34	336.32	292.31	1282.78	28%
MOS	NA	37.09	19.07	16.57	72.73	NA	81.77	42.04	36.53	160.34	NA
FG	NA	37.09	19.07	16.57	72.73	NA	81.77	42.04	36.53	160.34	NA
Nonpoint Sources											
LA	2213.76	5177.23	413.78	1.24	7806.01	5,137.00	11413.84	912.23	2.73	17209.31	55%
MOS	276.72	647.15	51.72	0.16	975.75	610.06	1426.72	114.02	0.35	2151.16	NA
FG	276.72	647.15	51.72	0.16	975.75	610.06	1426.72	114.02	0.35	2151.16	NA
TMDL	2767.20	6843.42	707.91	167.29	10484.83	6,357.12	15087.16	1560.67	368.8	23115.09	NA

Table 6.2. Winter DO TMDL for Subsegment 100501 (Bayou Dorcheat).

	Oxygen Demand (kg/day) from:					Oxygen Demand (lbs/day) from:					Percent Reduction Needed
	SOD	CBODu	Organic Nitrogen	Ammonia Nitrogen	Total	SOD	CBODu	Organic Nitrogen	Ammonia Nitrogen	Total	
Point Sources											
WLA	NA	468.52	192.66	212.79	873.97	NA	1032.91	424.74	469.12	1926.77	0%
MOS	NA	58.57	24.08	26.60	109.25	NA	129.12	53.09	58.64	240.86	NA
FG	NA	58.57	24.08	26.60	109.25	NA	129.12	53.09	58.64	240.86	NA
Nonpoint Sources											
LA	1360.17	7592.85	726.51	18.68	9698.19	2998.66	16739.37	1601.68	41.18	21380.85	34%
MOS	170.02	949.10	90.81	2.33	1212.27	374.83	2092.41	200.20	5.14	2672.60	NA
FG	170.02	949.10	90.81	2.33	1212.27	374.83	2092.41	200.20	5.14	2672.60	NA
TMDL	1700.21	10076.71	1148.95	289.33	13215.2	3748.32	22215.34	2533	637.86	29134.54	NA

Table 6.3. Flows, concentrations, and loads for point sources included in DO TMDL.

NPDES Number	Name of discharger	Flow rate (gpd)	Concentrations			Loads[B]		
			BOD_5 or $CBOD_5$ (mg/L)	Ammonia Nitrogen (mg/L)	Organic Nitrogen (mg/L)	BOD_5 or $CBOD_5$ (lbs/day)	Ammonia Nitrogen (lbs/day)	Organic Nitrogen (lbs/day)
LA0032301	Cullen WWTP	300,000	10.0	6.08	12.16A	32.39	5.14	2.58
LAG570016	Dixie Inn	4100	10.0	3.33	1.67	8.15	1.18	0.59
LA0038130	Minden WWTP	2440000	10.0	3.33	1.67	133.14	15.40	7.76
LA0005312	Cotton Valley Refinery	392000	15.0	0.0	0.00	63.99	0.00	0.00
LA0020401	Cotton Valley STP	150000	10.0	3.33	1.67	16.32	2.36	4.73
LA0033227	Springhill STP	1500000	5.0/10.0	2.0	4.00[A]	81.61/ 163.23	14.19	28.39
LA0104647	Sarepta STP	150000	10.0	0.0	0.00	16.32	0.00	0.00
LAG541088	Minden Truck Center	7000	30.0	0.0	0.00	2.35	0.00	0.00
LAG540265	Meadowbrook Home	5000	30.0	0.0	0.00	1.57	0.00	0.00
LAG540507	Twin Oaks Subdivision	19000	30.0	0.0	0.00	6.27	0.00	0.00
LAG540538	Oaktree Apartments	11000	30.0	0.0	0.00	3.5	0.00	0.00
LAG540944	Mousers Home Place	16000	30.0	0.0	0.00	5.29	0.00	0.00
100501 Total Loads:						370.9	38.27	44.05

A: Assumed to be two times ammonia nitrogen permit limit.
B: Loads of organic nitrogen and ammonia nitrogen in this table represent loads of nitrogen, not oxygen demand.

7.0 SENSITIVITY ANALYSES

All modeling studies necessarily involve uncertainty and some degree of approximation. Therefore it is of value to consider the sensitivity of the model output to changes in model coefficients, and in the hypothesized relationships among the parameters of the model. The sensitivity analyses were performed by allowing the LA-QUAL model to vary one input parameter at a time while holding all other parameters to their original value. The calibration simulation was used as the baseline for the sensitivity analysis. The percent change of the model's minimum DO projections to each parameter is presented in Table 7.1. Each parameter was varied by ±30%, except for temperature, which was varied ±2ºC.

Values reported in Table 7.1 are sorted by percent change in minimum DO from largest absolute percent change to the smallest. Reaeration, depth, and SOD (benthal demand) were the parameters to which DO was most sensitive.

Table 7.1. Summary of results of sensitivity analyses.

Input Parameter	Parameter Change	Predicted minimum DO (mg/L)	Percent Change in Predicted DO (%)
Baseline	--	1.91	NA
Nonpoint Source CBOD	30%	0.85	-55.50%
Waterbody Reaeration	-30%	1.02	-46.60%
Waterbody Reaeration	30%	2.7	41.36%
Benthal Demand	-30%	2.64	38.22%
Waterbody Depth	-30%	1.44	-24.61%
Waterbody Depth	30%	2.3	20.42%
Nonpoint CBOD	-30%	2.27	18.85%
Benthal Demand	30%	1.56	-18.32%
Initial Temperatures	-2ºC	2.14	12.04%
Initial Temperatures	2ºC	1.8	-5.76%
Nonpoint Sources Organic N	-30%	1.94	1.57%
Organic Nitrogen Decay Rate	-30%	1.93	1.05%
Nonpoint Source Organic N	30%	1.89	-1.05%
Headwater DO	-30%	1.9	-0.52%
Headwater Organic Nitrogen	-30%	1.92	0.52%
Headwater Organic Nitrogen	30%	1.9	-0.52%
Ammonia Decay Rate	-30%	1.91	0.00%
CBOD Aerobic Decay Rate	-30%	1.91	0.00%
Headwater Ammonia	-30%	1.91	0.00%
Headwater CBOD	-30%	1.91	0.00%
Headwater Flow	-30%	1.91	0.00%
Wasteload Ammonia	-30%	1.91	0.00%
Wasteload CBOD	-30%	1.91	0.00%
Wasteload DO	-30%	1.91	0.00%
Wasteload Flow	-30%	1.91	0.00%
Wasteload Organic Nitrogen	-30%	1.91	0.00%
Ammonia Decay Rate	30%	1.91	0.00%
CBOD Aerobic Decay Rate	30%	1.91	0.00%
Headwater Ammonia	30%	1.91	0.00%
Headwater CBOD	30%	1.91	0.00%
Headwater DO	30%	1.91	0.00%
Headwater Flow	30%	1.91	0.00%
Organic Nitrogen Decay Rate	30%	1.91	0.00%
Wasteload Ammonia	30%	1.91	0.00%
Wasteload CBOD	30%	1.91	0.00%
Wasteload DO	30%	1.91	0.00%
Wasteload Flow	30%	1.91	0.00%
Wasteload Organic Nitrogen	30%	1.91	0.00%

8.0 OTHER RELEVANT INFORMATION

This TMDL has been developed to be consistent with the state anti-degradation policy (LAC 33:IX.1109.A).

This TMDL report does not include an implementation plan. Implementation plans are not required for TMDLs under current federal regulations. Implementation plans can be developed most effectively and efficiently on the state and local level.

LDEQ will work with other agencies such as local Soil Conservation Districts to implement nonpoint source BMPs in the watershed through the Section 319 programs. LDEQ will also continue to monitor the waters to determine whether standards are being attained.

In accordance with Section 106 of the Federal Clean Water Act, and under the authority of the Louisiana Environmental Quality Act, LDEQ has established a comprehensive program for monitoring the quality of the state's surface waters. The LDEQ Surveillance Section collects surface water samples at various locations, utilizing appropriate sampling methods and procedures for ensuring the quality of the data collected. The objectives of the surface water monitoring program are to determine the quality of the state's surface waters, to develop a long-term data base for water quality trend analysis, and to monitor the effectiveness of pollution controls. The data obtained through the surface water monitoring program is used to develop the state's biennial 305(b) report (Water Quality Inventory) and the 303(d) list of impaired waters. This information is also utilized in establishing priorities for the LDEQ nonpoint source program.

LDEQ has implemented a watershed approach to surface water quality monitoring. Through this approach, the entire state is sampled over a 4-year cycle. Long-term trend monitoring sites at various locations on the larger rivers and Lake Pontchartrain are sampled throughout the 4-year cycle. Sampling is conducted on a monthly basis to yield approximately 12 samples per site each year the site is monitored. Sampling sites are located where they are considered to be representative of the waterbody. Under the current monitoring schedule, approximately one half of the state's waters are newly assessed for each 305(b) and 303(d) listing biennial cycle, with sampling occurring statewide each year. The 4-year cycle follows an initial 5-year rotation that covered all basins in the state according to the TMDL priorities. This will allow LDEQ to determine whether there has been any improvement in water quality following implementation of the TMDLs. As the monitoring results are evaluated at the end of each year, waterbodies may be added to or removed from the 303(d) list.

9.0 PUBLIC PARTICIPATION

Federal regulations require USEPA to notify the public and seek comment concerning TMDLs it prepares. The TMDL in this report was developed under contract to USEPA, and USEPA held a public review period seeking comments, information, and data from the public and any other interested parties. The notice for the public review period was published in the Federal Register on October 25, 2007, and the review period closed on November 26, 2007.

Comments were received from LDEQ. These comments were used to revise this TMDL report. The comments and responses to these TMDLs are included in a separate document that includes comments on similar TMDLs with the same public review period.

USEPA will submit the final version of these TMDLs to LDEQ for implementation and incorporation into LDEQ’s current water quality management plan.

10.0 REFERENCES

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